Translation of Japanese Unexamined Patent Application

ABNORMALITY MONITORING SYSTEM

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SPECIFICATION

1. Title of the Invention

Abnormality Monitoring System

2. Claim

1. An abnormality monitoring system comprising:

a monitored region memory for storing a monitored region in advance; an image capture device for capturing an image of this monitored region and for creating an image signal; an image input means for performing analogue-to-digital conversion of said image signal; a current image memory for storing the current image that has been analogue-to-digital converted by said image input means; a reference image memory for storing a reference image indicative of a normal situation; a difference means for creating a difference image of said current image and said reference image [1]*; an image processing means for extracting the changed portions from said difference image; an abnormality decision means for determining an abnormality on the basis of comparing the output of said image processing means and the content of said monitored region memory; and output means for outputting the result of this decision;

said abnormality monitoring system being characterised in that:

it comprises an image capture field of view movement means for moving the image capture field of view in such manner that the image that is obtained is such that a monitored body within said monitored region shifts, in terms of the image, approximately parallel to the plane of a monitored subject [2]; and a position conversion means for obtaining the three-dimensional coordinates of said monitored body; and

it stores in advance, in said monitored region memory, three-dimensional coordinates indicative of said monitored region, and determines an abnormality by comparing the aforesaid two sets of three-dimensional coordinates. [3]

* Numbers in square brackets refer to Translator's Notes appended to the translation.

3. Detailed Description of the Invention

Technical field

The present invention belongs to the technical field pertaining to abnormality monitoring systems which employ image capture devices such as television cameras to detect the occurrence of an abnormality in a monitored region. The invention is used for example to detect the theft of paintings and the like.

Technical background

Hitherto, this kind of system has obtained the difference in brightness between respective pixels of an input image and a reference image, and after binarizing using a prescribed threshold, has counted the number of changed pixels in a predetermined monitored region, and has decided that there is an abnormality if this number of changed pixels exceeds a prescribed reference value (see Japanese Unexamined Patent Application, Pub. No. 60-007593).

For example, in the example of monitoring shown in FIG. 5, monitored subject 12 (a painting or the like) is located in monitored subject plane 13 (a wall or the like). In this case, in order to monitor this monitored subject 12 by means of image capture device 1 and to generate an alarm when it has been detected that an intruding body has approached near to monitored subject 12, the region outside non-detection region 15 – in the monitoring picture obtained by image capture device 1 and depicted in FIG. 6 – is designated as the monitored region, and an abnormality is detected by means of the method outlined above.

Note that coordinate axes 14 serve to clarify what directions each drawing is showing.

However, with the system described above, if monitored region 16 [4], which is the region – for example, a region inside a room – in which an intruding body can be detected, is viewed from image capture device 1, then bodies located on the same line of sight cannot be distinguished, and hence inevitably monitored region 16 ends up having the triangular shape shown by the oblique lines in FIG. 7. Consequently, a problem that has been encountered is that despite body 18 – for example – getting quite close to monitored subject 12, because body 18 is outside monitored region 16, no alarm is generated. Similarly, despite body 19 being comparatively distant from monitored subject 12, because it is within monitored region 16, the outcome is that an alarm is generated.

Object of the invention

The present invention has been devised in the light of the problem described above, and it is an object of the invention to provide an abnormality monitoring system capable of deciding,

in respect of a monitored region of predetermined arbitrary shape, whether or not a monitored body is located within this monitored region.

Disclosure of the invention

The present invention is an abnormality monitoring system comprising a monitored region memory for storing a monitored region in advance; an image capture device for capturing an image of this monitored region and for creating an image signal; an image input means for performing analogue-to-digital conversion of the aforesaid image signal; a current image memory for storing the current image that has been analogue-to-digital converted by the aforesaid image input means; a reference image memory for storing a reference image indicative of a normal situation; a difference means for creating a difference image of the aforesaid current image and the aforesaid reference image; an image processing means for extracting the changed portions from the aforesaid difference image; an abnormality decision means for determining an abnormality on the basis of comparing the output of the aforesaid image processing means and the content of the aforesaid monitored region memory; and output means for outputting the result of this decision. This abnormality monitoring system is characterised in that it comprises an image capture field of view movement means for moving the image capture field of view in such manner that the image that is obtained is such that a monitored body within the aforesaid monitored region shifts, in terms of the image, approximately parallel to the plane of the monitored subject; and a position conversion means for obtaining the three-dimensional coordinates of the aforesaid monitored body; and further characterised in that it stores in advance, in the aforesaid monitored region memory, three-dimensional coordinates indicative of the aforesaid monitored region, and determines an abnormality by comparing the aforesaid two sets of three-dimensional coordinates. The invention attains the above-mentioned objects on the basis of this system.

The invention will now be described on the basis of the drawings, which illustrate an embodiment thereof.

In FIG. 1, which is a block diagram showing an embodiment of the present invention, numeral 1 references an image capture device such as a television camera, and this serves to capture an image of the vicinity of for example a wall on which a painting or the like is being exhibited, and to create an image signal thereof. Numeral 2 references an image input means which serves for analogue-to-digital conversion of the aforesaid image signal. Numeral 3 references a current image memory, and this serves to store the current image that has been obtained by analogue-to-digital conversion by means of image input means 2 [5]. Numeral 4 references a reference image memory which serves to store in advance a reference image

indicative of a normal situation in which there is no abnormality. Numeral 5 references a difference means, and this serves to create a difference image based on brightness differences between the aforementioned current image and the aforementioned reference image. Numeral 6 references an image processing means which serves to extract only those portions at which there is a prescribed or larger brightness difference, on the basis of binarizing the aforementioned difference image.

Numeral 7 references an image capture field of view movement means, this serving to move the image capture field of view in such manner that the image that is obtained is such that a monitored body within the monitored region shifts, in terms of the image, approximately parallel to the plane of the monitored subject. As shown in FIG. 2, this can be implemented for example by causing image capture device 1 to move reciprocally in the X-axis direction. It can also be implemented by swinging the head of image capture device 1 or by installing a rotating mirror in front of image capture device 1.

Numeral 8 references a position conversion means for obtaining the three-dimensional coordinates of a monitored body. It is assumed in FIG. 3 that the coordinates of extracted body 22 on the image that has been captured by image capture device 1 at present time *t* are (x_1, y_1) (though these coordinates are not illustrated in FIG. 3), and that the coordinates of extracted body 22 on the image that has been captured by image capture device 1′ which has shifted, at time $t+\Delta t$, by Δx in a direction parallel to the X-axis direction, have become (x_2, y_2) (again, these coordinates are not illustrated in FIG. 3). All bodies located on line of view 20 of image capture device 1 have their image captured at the same coordinates (x_1, y_1), and all bodies on line of view 20′ of image capture device 1′ have their image captured at the same coordinates (x_2, y_2). However, the only body located at a position which is at an angle θ_1 in the X-axis direction from centre line 21 of image capture device 1, and at an angle θ_2 in the X-axis direction from centre line 21′ of image capture device 1′, is body 22 on the intersection of line of view 20 and line of view 20′. Writing L for the distance in the Z direction from image capture device 1 to body 22 gives:

$$L\tan\theta_1 - L\tan\theta_2 = \Delta x$$

so that:

$$L = \Delta x/(\tan\theta_1 - \tan\theta_2)$$

Δx is obtained as the distance over which image capture device 1 moves; and θ_1 and θ_2 are obtained, in a manner to be described below, from the coordinates of body 22 when its image is taken, in accordance with the focal length of image capture device 1, the size of the lens, and the resolution. Accordingly, the distance L in the Z direction from image capture

device 1 to body 22 can be calculated. In FIG. 4, the horizontal angle of view [6] δ_x and the perpendicular angle of view δ_y [7] of image capture device 1 are values which are determined by the focal length of image capture device 1 being used and by the size of its lens. Therefore, writing W for the horizontal resolution of the image input means and H for the perpendicular resolution, the angles θ_x in the X-axis direction and θ_y in the Y-axis direction from line of view 21 to body 22 – line of view 21 passing through the centre of image capture device 1 – are given by the following, on the assumption that the coordinates of the body when its image is taken are (x, y) (these are not shown in FIG. 4): [8]

$$\theta_x = (x - W/2) \cdot \delta_x / W$$

$$\theta_y = (y - H/2) \cdot \delta_y / H$$

The previously mentioned θ_1 and θ_2 are found as respective angles θ when body 22 has its image captured by image capture device 1 and image capture device 1′.

Hence distance L in the Z direction from image capture device 1, angle θ_x in the X-axis direction from line of view 21, and angle θ_y in the Y-axis direction from line of view 21, are found in these ways, and therefore the three-dimensional coordinates of body 22 can be obtained.

Consequently, if the three-dimensional coordinates of body 22 are utilised, it is possible to obtain a monitored region of arbitrary shape such as for example region 17 surrounded by the broken line shown in FIG. 7. [9]

Next, referring again to FIG. 1, numeral 9 references an abnormality decision means, and this serves for deciding whether or not body 22 is located in monitored region 17, on the basis of comparing the three-dimensional coordinates of body 22 that have been obtained by position conversion means 8 and the three-dimensional coordinates indicative of monitored region 17, these having been stored in advance in monitored region memory 10 to be described below.

Numeral 10 references the monitored region memory, and this serves to store in advance the three-dimensional coordinates indicative of the region which it is desired to monitor.

Numeral 11 references an output means, and this serves to generate an alarm on the basis of the output of abnormality decision means 9.

Let it be assumed that body 22 has entered the field of view of image capture device 1 in an abnormality monitoring system of the sort described above. The three-dimensional coordinates of body 22 are found by position conversion means 8 by moving the field of view

by means of image capture field of view movement means 7. (It is also feasible for image capture field of view movement means 7 to cause image capture device 1 to be constantly moving.) These three-dimensional coordinates are compared, by abnormality decision means 9, with the three-dimensional coordinates indicative of the monitored region, these having been stored in advance in monitored region memory 10, whereupon abnormality decision means 9 decides whether or not body 22 is located in monitored region 17. If body 22 is located in monitored region 17, an alarm is generated by output means 11.

Advantageous effects of the invention

As has been described above, the present invention is an abnormality monitoring system comprising a monitored region memory for storing a monitored region in advance; an image capture device for capturing an image of this monitored region and for creating an image signal; an image input means for performing analogue-to-digital conversion of the aforesaid image signal; a current image memory for storing the current image that has been analogue-to-digital converted by the aforesaid image input means; a reference image memory for storing a reference image indicative of a normal situation; a difference means for creating a difference image of the aforesaid current image and the aforesaid reference image; an image processing means for extracting the changed portions from the aforesaid difference image; an abnormality decision means for determining an abnormality on the basis of comparing the output of the aforesaid image processing means and the content of the aforesaid monitored region memory; and output means for outputting the result of this decision. This abnormality monitoring system of the invention is adapted to comprise an image capture field of view movement means for moving the image capture field of view in such manner that the image that is obtained is such that a monitored body within the aforesaid monitored region shifts, in terms of the image, approximately parallel to the plane of the monitored subject; and a position conversion means for obtaining the three-dimensional coordinates of the aforesaid monitored body. The abnormality monitoring system of the invention stores in advance, in the aforesaid monitored region memory, three-dimensional coordinates indicative of the aforesaid monitored region, and determines an abnormality by comparing the aforesaid two sets of three-dimensional coordinates. The present invention therefore provides an abnormality monitoring system which is capable of deciding, in respect of a monitored region of predetermined arbitrary shape, whether or not a monitored body is within that region.

4. Brief Description of the Drawings

FIG. 1 is a block diagram showing an embodiment of the present invention.

FIG. 2 is a front view showing the nature of the movement of an image capture device in the same.

FIG. 3 serves to clarify the principles of the same.

FIG. 4 serves to clarify the principles of the same.

FIG. 5 is a schematic view showing the nature of monitoring in a conventional example.

FIG. 6 is a monitoring screen view in the same.

FIG. 7 is a schematic view showing a monitored region in the same.

Key to referencing numerals

1 ········ image capture device

2 ········ image input means

3 ········ current image memory

4 ········ reference image memory

5 ········ difference means

6 ········ image processing means

7 ········ image capture field of view movement means

8 ········ position conversion means

9 ········ abnormality decision means

10 ······ detection region memory [10]

11 ······ output means

FIG. 1

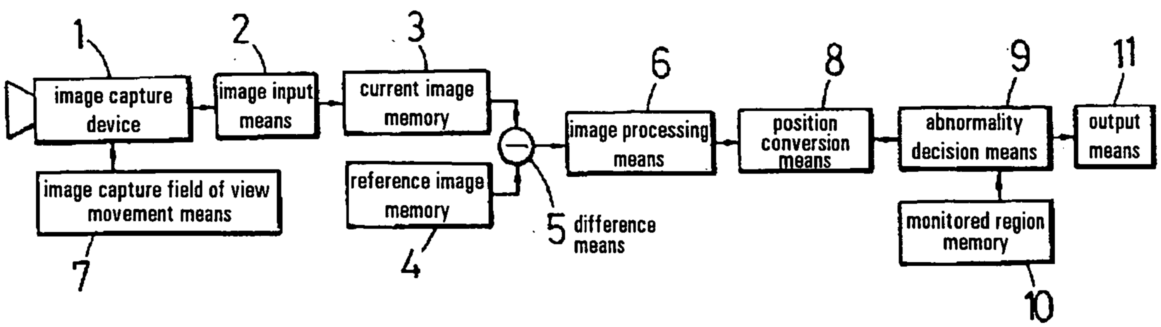


FIG. 2

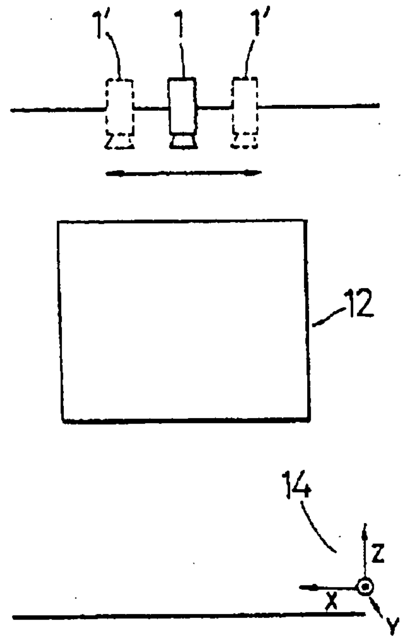


FIG. 3

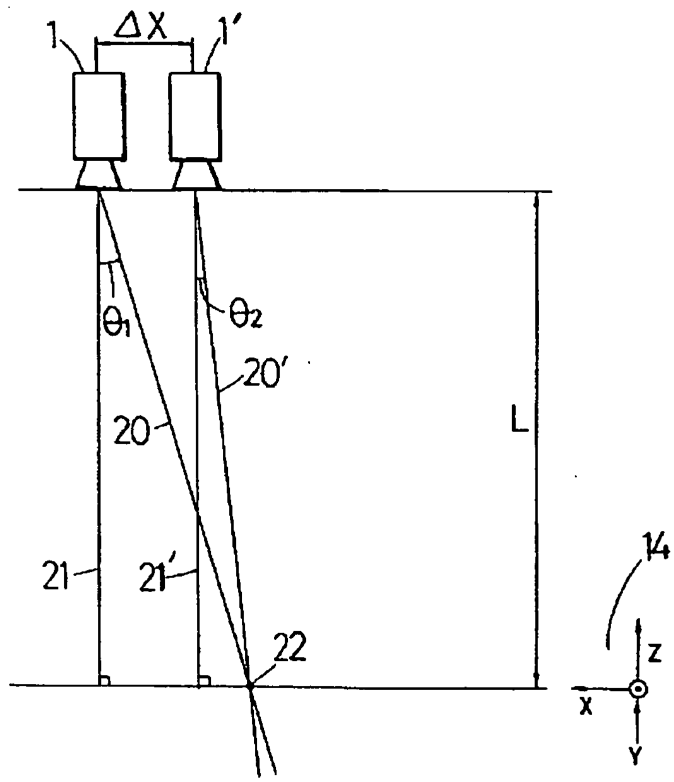


FIG. 4

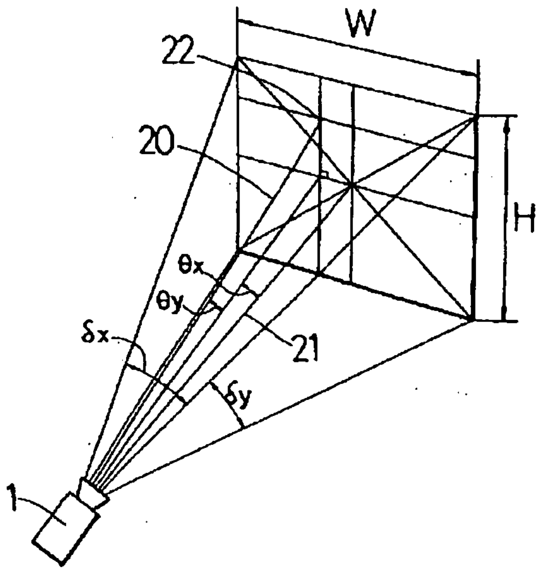


FIG. 5

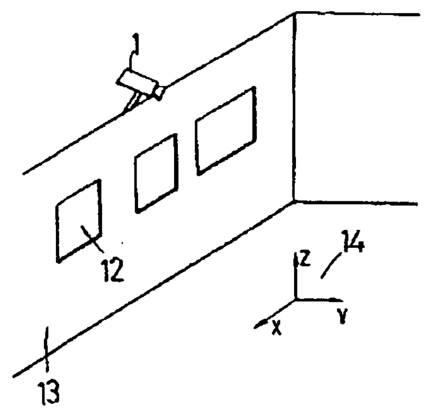


FIG. 6

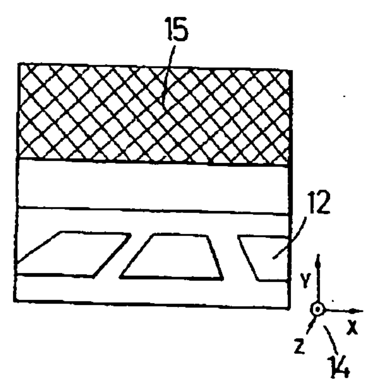
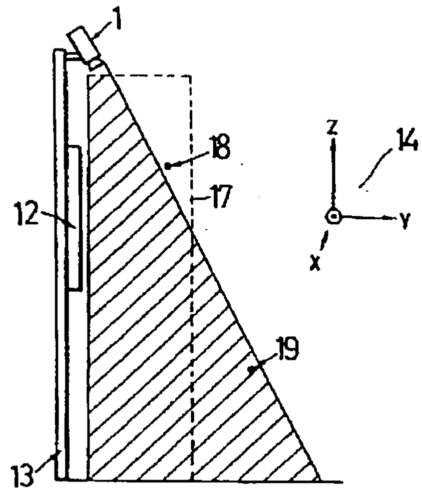


FIG. 7



TRANSLATOR'S NOTES

1. Sic. The nature of the "difference image" is not made more explicit than this in this part of the claim.

2. This part of the claim is not very clear. It becomes clearer with reference to FIG. 3. Note that the term "monitored body" is used throughout the Japanese document to signify a potentially intruding body that is being monitored, and the term "monitored subject" is used to signify the object being protected by the monitoring system, e.g., a painting hanging on a wall.

3. The Japanese that I have translated as "by comparing the aforesaid two sets of three-dimensional coordinates" is literally "by comparing both the aforesaid three-dimensional coordinates". In any case, the writer's meaning is that the 3-d coordinates found for a detected and monitored body are compared with the set of 3-d coordinates that define the region in which intrusion by a body triggers an alarm.

4. Note that none of the drawings explicitly shows this monitored region 16. However, it has been defined, two paragraphs previously, as the region outside non-detection region 15 (see FIG. 6).

5. The Japanese text here erroneously has "image input means 3". I have corrected this to "image input means 2".

6. The Japanese term that I have translated as "angle of view" may also be translated as "angle of field" or "coverage angle".

7. In this context, the y-direction is perpendicular to the plane (e.g., the wall) in which the monitored subject is located, and the x-direction is parallel to the plane in question.

8. I have studied the first of these equations repeatedly, but cannot derive it from the information given in the text and in FIG. 4. Moreover, substitution of the limiting values for x, namely x=0 and x=W/2, into the first equation results in absurdities, which suggests that the equation is erroneous. These comments presumably apply, *mutatis mutandis*, to the second equation.

9. Sic. This is an oddly expressed statement. The writer presumably means something along the lines of: "a monitored region of arbitrary shape can be defined on the basis of application of the same method, described above in relation to body 22, for obtaining 3-d coordinates."

10. Sic. Everywhere else, the circuit block referenced 10 is called the monitored region memory.